Introduction to Natural Hazards

Chapter 1

Framework for Each Chapter

- Learn the Objectives of the Chapter
- Introduction to each hazard
- Examine the processes of the hazard
- The cycle of the hazard
- Geographic regions at risk of this hazard
- Natural functions of the hazard
- Human interaction with the hazard
- Minimizing the risk of the hazard
- Looking at the Perception of and Adjustments to the risks of the hazard

Learning Objectives

1. Learn the difference between a disaster and a catastrophe
2. Learn the components and processes of the geologic cycle
3. Understand the scientific method
4. Understand the basics of risk assessment
5. Recognize natural hazards that cause disasters are generally high energy events caused by natural earth processes
6. Understand the concept that the magnitude of a hazardous event is inversely related to its frequency
7. Understand how natural hazards my be linked to one another and to the physical environment
8. Recognize that increasing human population and poor land-use practices compound the effects of natural disasters and catastrophes

Why Study Natural Hazards?

- To learn about the internal and external forces of the earth and how they interact with civilization
- To learn how civilization can better adjust and adapt to these forces
- To learn to appreciate and respect the awe of these processes and their effects

Processes: Internal and External

- **Process – the physical, chemical, and biological ways by which events effect the earth's surface.**
  - **Internal**
    - **Tectonic**
      - Volcanic eruptions
      - Earthquakes
  - **External**
    - **Climate and Weather** – Part of the Hydrological Cycle
      - Hurricanes and Tornados
    - **Mass Wasting of the Earth's Surface**
      - Landslides
      - Flooding

Hazard, Disaster, or Catastrophe

- **Natural Hazards**
  - A natural Process and/or Event that is a potential threat to human life and property.
    - The Event is not the problem, but the danger to humans and their property determines if the Event is to be a Hazard.
    - Affects millions of people around the world

      - Blizzards and Ice Storms
      - Wildfires
      - Tsunamis
      - Droughts
      - Subsidence
      - Coastal erosions
      - Impacts from asteroids and comets

Disasters

- **What is A Disaster?**

  - A Hazardous Event that occurs over a limited time span in a defined area

    - Criteria:
      - Ten or more people killed
      - 100 or more people affected
      - A state of emergency is declared
      - International assistance is requested

  - During past few decades, natural disasters have killed several million people, average loss of life about 80,000 people.

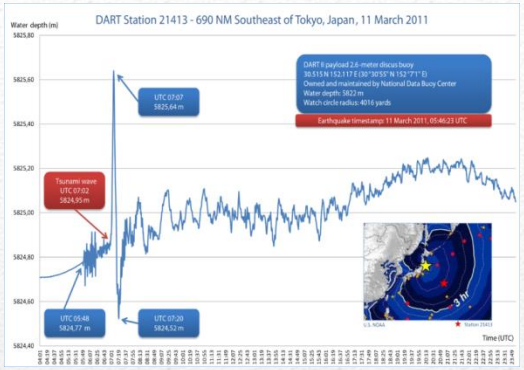
  - Financial loss – exceeds $50 Billion a year.

Catastrophes

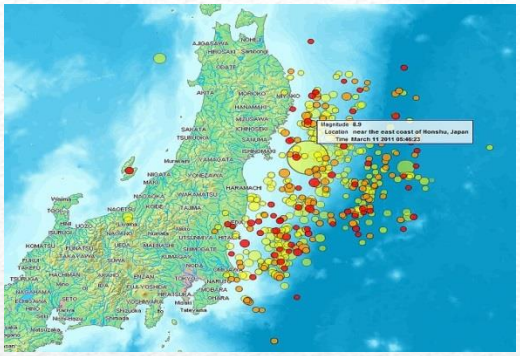
- **What is a Catastrophe**

  - A massive disaster that requires significant expenditure of money and long time recovery to take place.

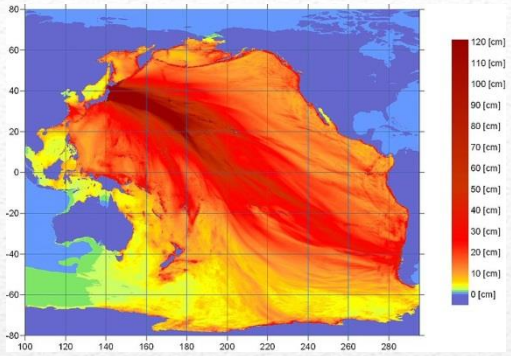
    - Some of the most current Catastrophes are:
      - Hurricane Katrina - 2005
      - Haiti Earthquake - 2011
      - Indonesia Earthquake and Tsunami -2004
      - Bangladesh Hurricane - 1991
      - Japan Earthquake and Tsunami- 2011
      - The Northeaster and Hurricane Sandy Combination - 2012



Seismic reading of 9.0 Earthquake



Preceding earthquakes



Tsunami path

Sandy in the beginning

Sandy and the Northeaster

West Virginia snow from Sandy

DEATHS AND DAMAGE CAUSED BY NATURAL HAZARDS

- To compare the effects of various natural hazards, we look at the greatest loss of life.

- Next we look at the property damage
  - How much was the cost
  - How many people does this damage effect
  - The most important to look at is the potential to produce a catastrophe.

Which Hazards Could Cause Catastrophes

- **<u>High risk hazards</u>**
  - Floods
  - Hurricanes
  - Tornadoes
  - Earthquakes
  - Volcanic Eruptions
  - Large Wildfires
  - Heat Waves

Which Hazards Could Cause Catastrophes

- **Moderate and low risk hazards**
  - Landslides (effects a smaller area)
  - Drought
  - Coastal Erosion
  - Frost
  - Lightening
  - Expansive Soils
  - Extra Terrestrial impact

Understanding Hazards Through History

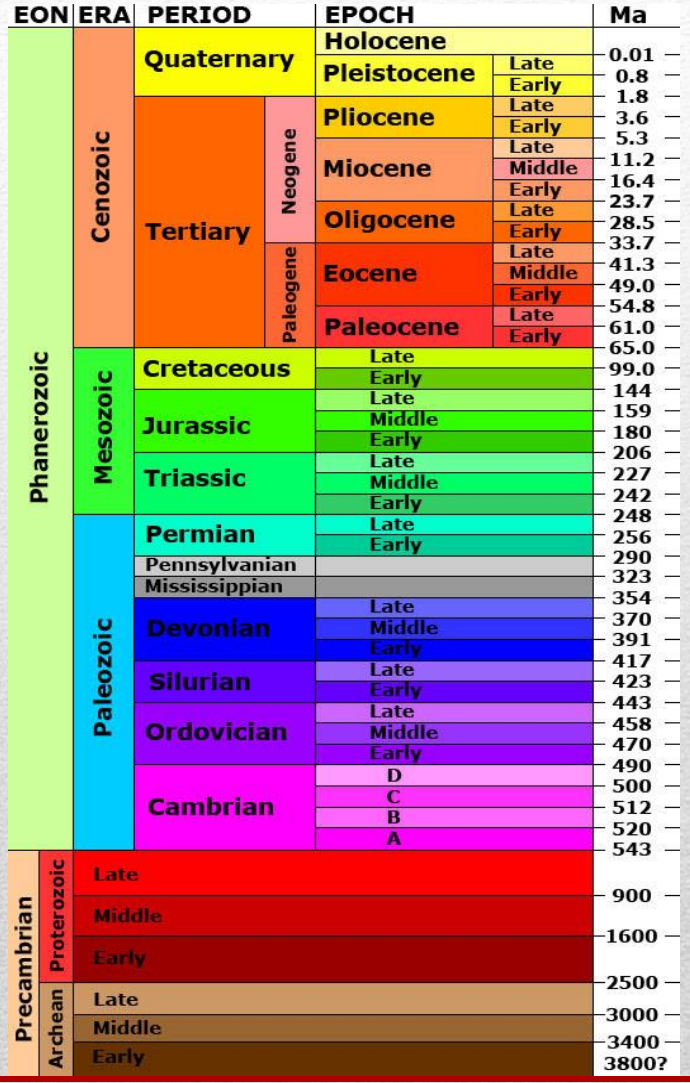
- Natural Hazards are repetitive through history
- By studying the history of natural hazard events, we can gain information for a hazard-reduction plan.

  - Some of these plans are
    - Better building requirements (for earthquakes and floods)
    - Where are natural flood plains
    - Understand the land for potential landslides

- To totally understand Nature and all its hazards, we must study and understand information to gain a background of the natural processes of the earth

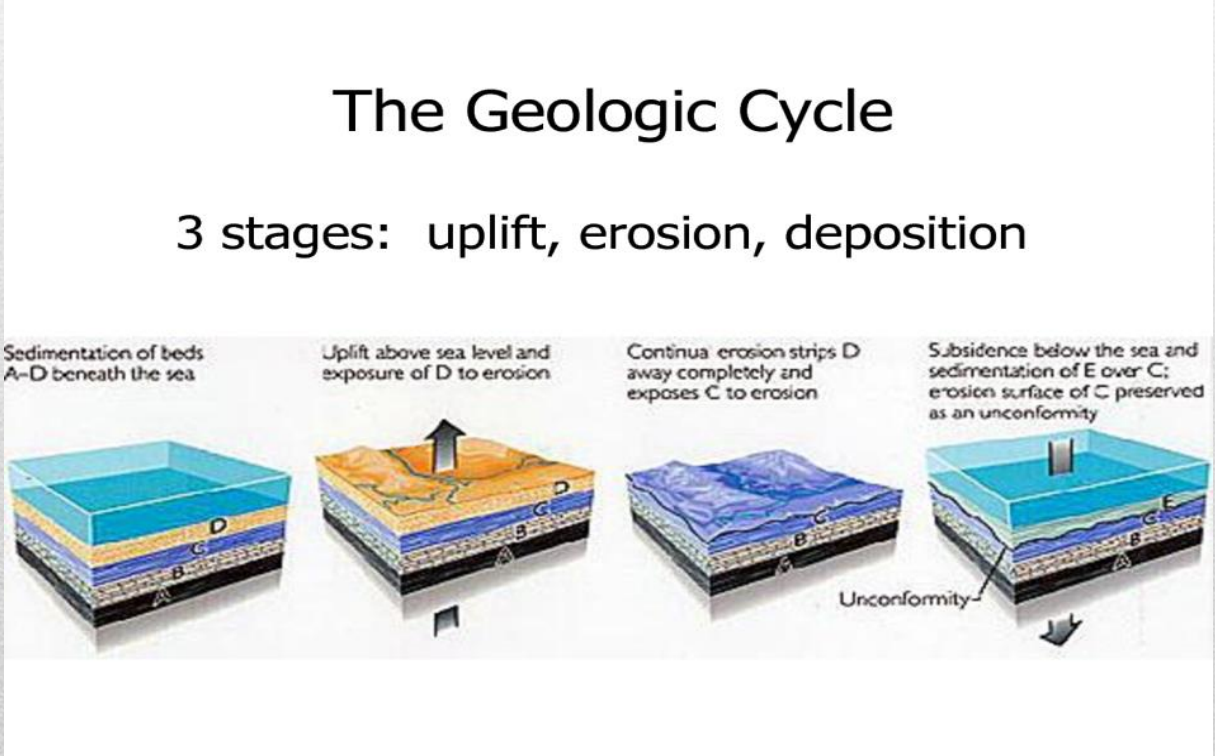
Geologic Time

- Earth is about 4.6 billion years old
- Age of the dinosaurs 160 million years ago
- Rocky Mountains uplifted 65 million years ago



Geologic Cycle

- The Geologic conditions and materials largely govern the type, location, and intensity of natural processes.
- An understanding of the components and dynamics of the geologic cycle will explain these relationships



Geologic Cycle

- **What describes the Geologic Cycle**
  - Throughout the 4.6 billion years of the Earth's history materials on or near the earth's surface have been created, maintained, and destroyed by numerous physical, chemical, and biological processes.
  - These processes produce earth materials, land, water, and atmosphere, necessary for our survival.
  - These processes are called the **geologic cycle** made up of
    - **The Tectonic Cycle**
    - **The Rock Cycle**
    - **The Hydrology Cycle**
    - **The Biogeochemical Cycle**

Tectonic Cycle

- ***Tectonic*** refers to the large-scale geologic processes that form and deform the Earth's crust and produce landforms such as ocean basins, and continents, and mountains
- The **Tectonic cycle** involves the creation, movement, and destruction of these tectonic plates.
- It is responsible for the production and distribution of rock and mineral resources invaluable to modern civilization, as well as hazards such as volcanoes and earthquakes.

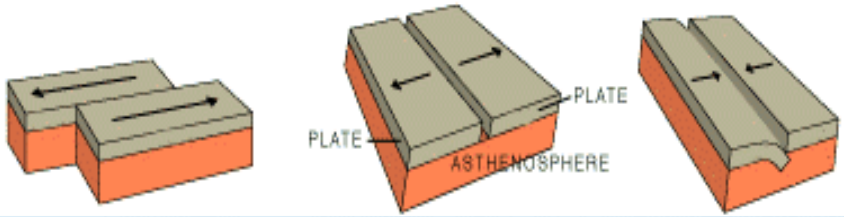
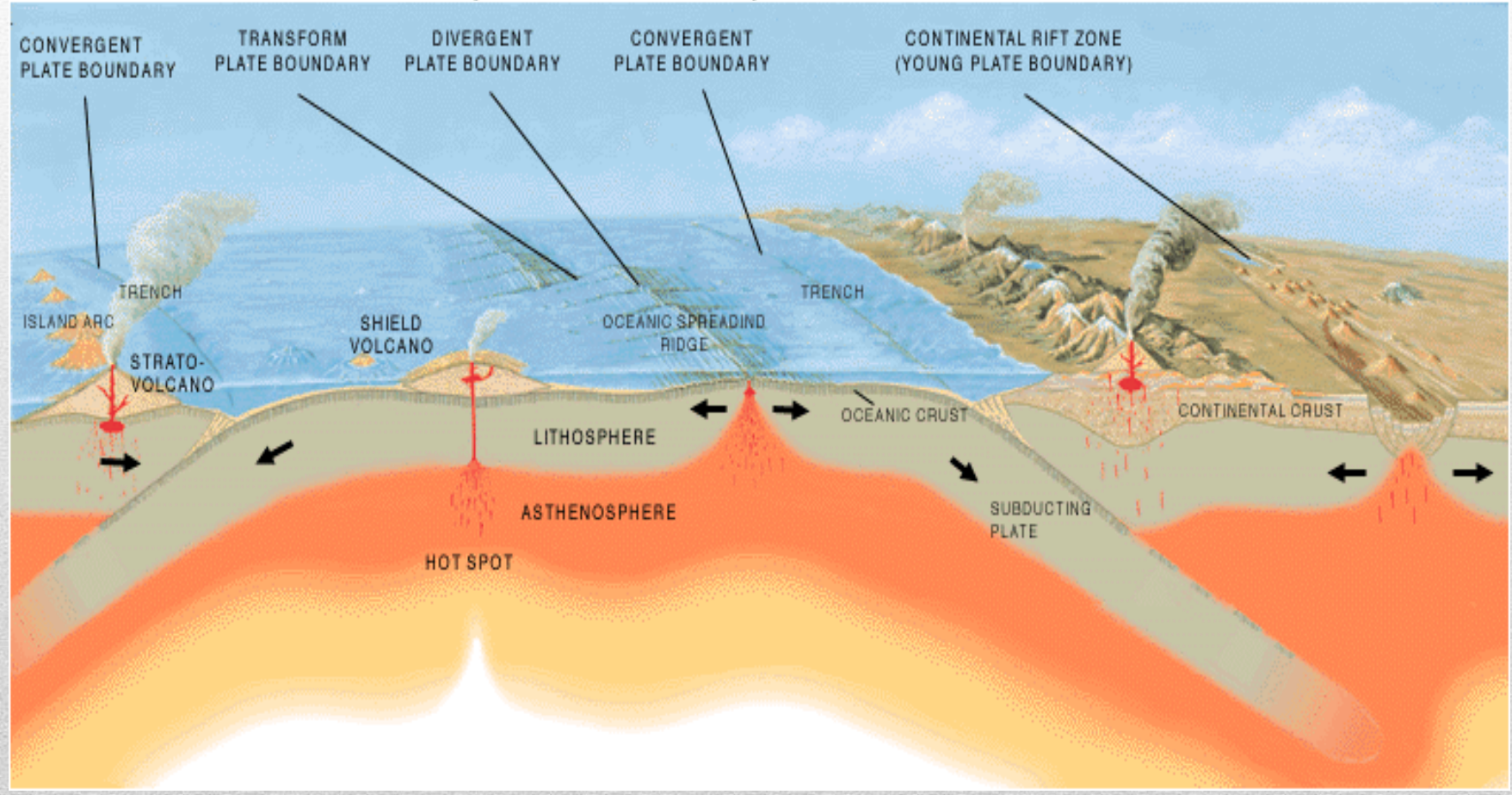
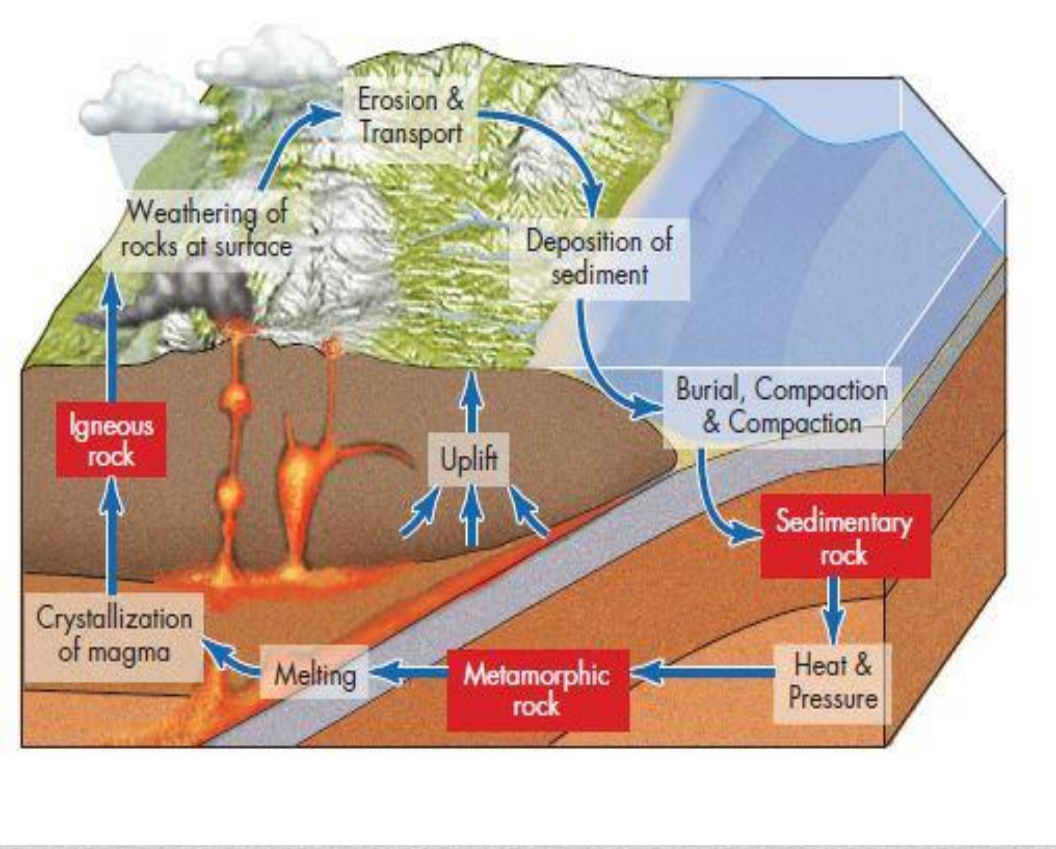


PLATE
PLATE
ASTHENOSPHERE


CONVERGENT PLATE BOUNDARY
TRANSFORM PLATE BOUNDARY
DIVERGENT PLATE BOUNDARY
CONVERGENT PLATE BOUNDARY
CONTINENTAL RIFT ZONE (YOUNG PLATE BOUNDARY)
TRENCH
ISLAND ARC
STRATO-VOLCANO
SHIELD VOLCANO
OCEANIC SPREADIND RIDGE
TRENCH
LITHOSPHERE
OCEANIC CRUST
CONTINENTAL CRUST
ASTHENOSPHERE
SUBDUCTING PLATE
HOT SPOT

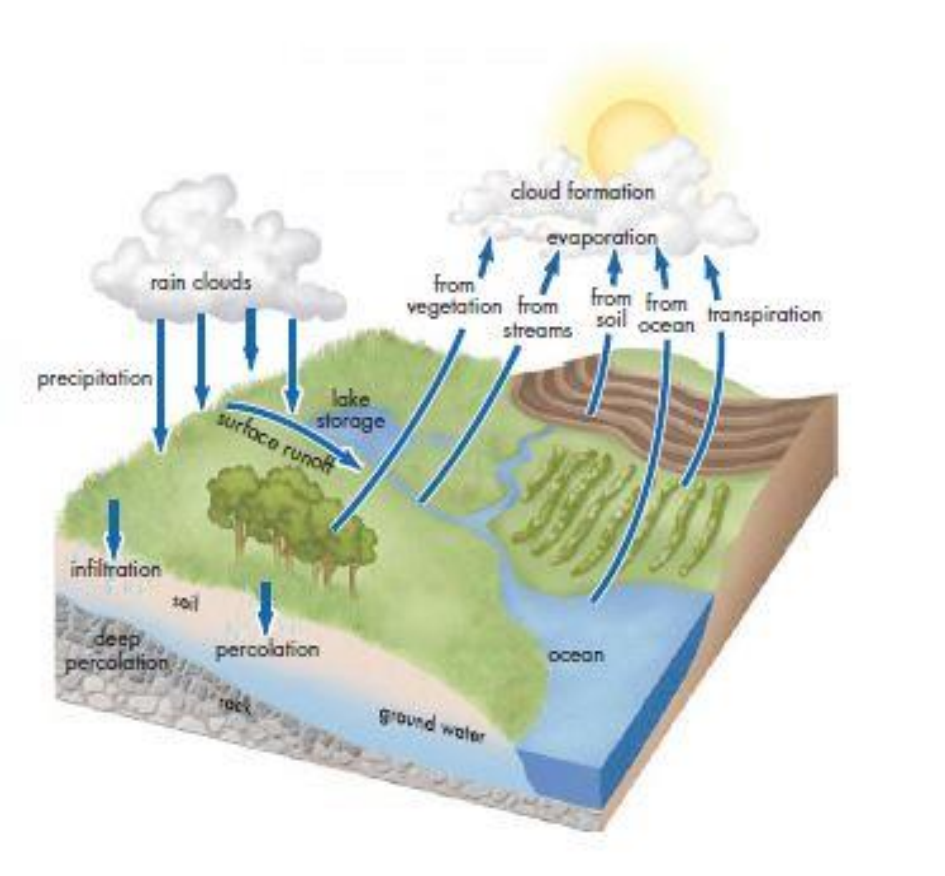
Rock Cycle

- Rock Cycle
  - Rocks are aggregates of one or more ***minerals***.
  - It is the largest geologic subcycle and it is linked to all the other subcycles
    - Depends on:
      - The tectonic cycle for heat and energy
      - The biogeochemical cycle for materials
      - The hydrologic cycle for water.



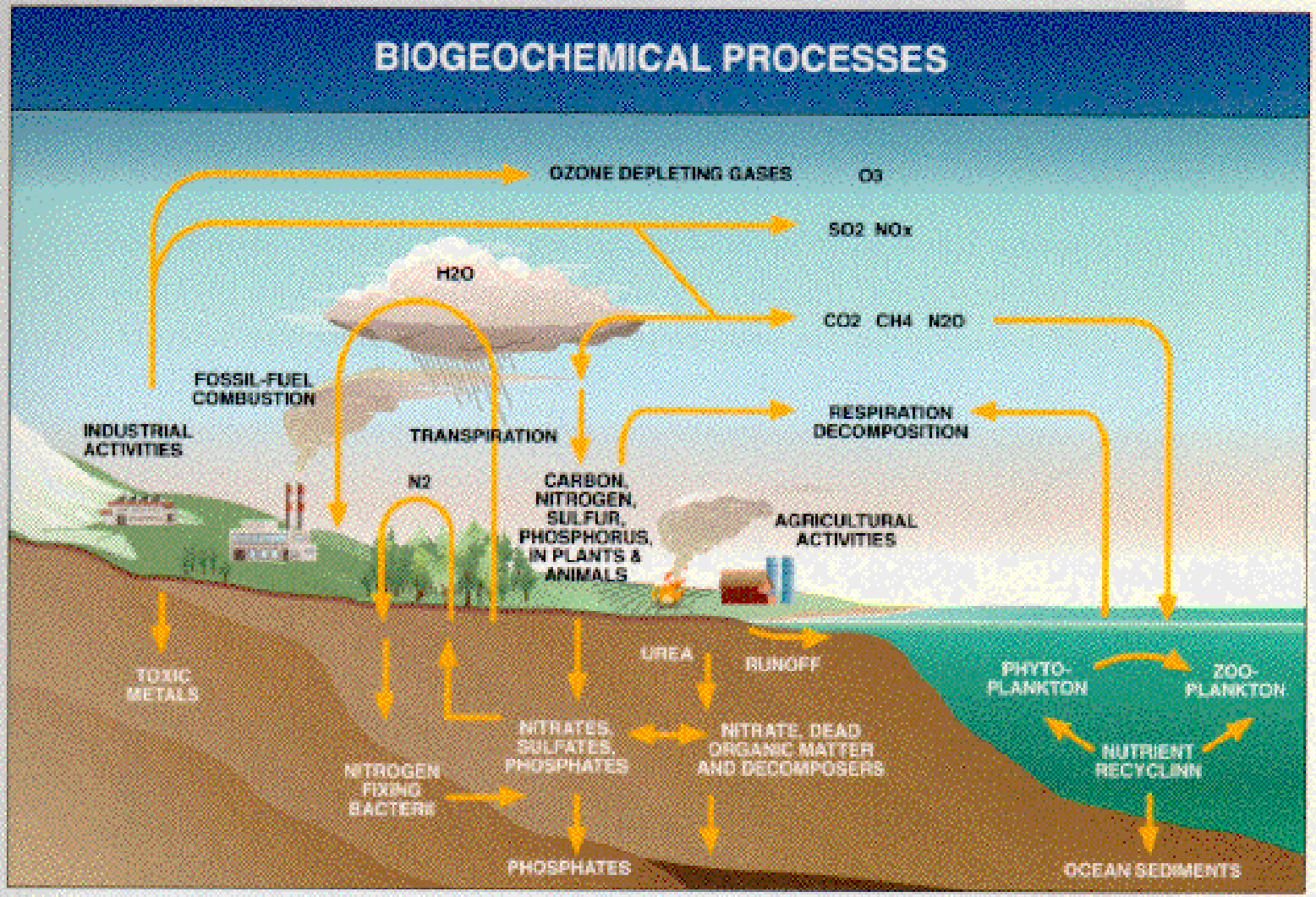
Hydrologic Cycle

- Hydrologic Cycle
  - Water Vapor in the air returns to the earth through precipitation
  - Moves through the earth in streams, ground water and evaporation or evapotranspiration
  - Returns to the oceans and the air to start again



Biogeochemical Cycles

- The transfer or cycling of a **chemical element or elements** through the atmosphere, lithosphere, hydrosphere, and biosphere
- The **tectonic cycle** provides water from volcanic processes as well as heat and energy used to for and change the earth materials
- The **rock and hydrologic cycles** are involved in many processes that transfer and store chemical in water, soil and rock.
- **Biogeochemical cycles** can most easily be described as the **transfer of chemical elements through a series of storage compartments or reservoirs**
  - Air, Soil, Groundwater and Vegetations


BIOGEOCHEMICAL PROCESSES
OZONE DEPLETING GASES
O3
SO2 NOx
H2O
CO2 CH4 N2O
FOSSIL-FUEL COMBUSTION
INDUSTRIAL ACTIVITIES
TRANSPIRATION
RESPIRATION DECOMPOSITION
N2
CARBON, NITROGEN, SULFUR, PHOSPHORUS, IN PLANTS & ANIMALS
AGRICULTURAL ACTIVITIES
TOXIC METALS
UREA
RUNOFF
PHYTO-PLANKTON
ZOO-PLANKTON
NITRATES, SULFATES, PHOSPHATES
NITRATE, DEAD ORGANIC MATTER AND DECOMPOSERS
NUTRIENT RECYCLING
NITROGEN FIXING BACTERIA
PHOSPHATES
OCEAN SEDIMENTS

Fundamental Concepts for Understanding Natural Processes as Hazards

- **Five Basic Concepts to Understanding Natural Hazards**

1. Hazards are **predictable from scientific evaluation**
2. **Risk analysis is an important component** in understanding the effects of hazardous processes
3. **Linkages exists between different natural hazards** as well as between hazards and the physical environment
4. **Hazardous events that previously produced disasters are now producing catastrophes**
5. **Consequences of hazards can be minimized**

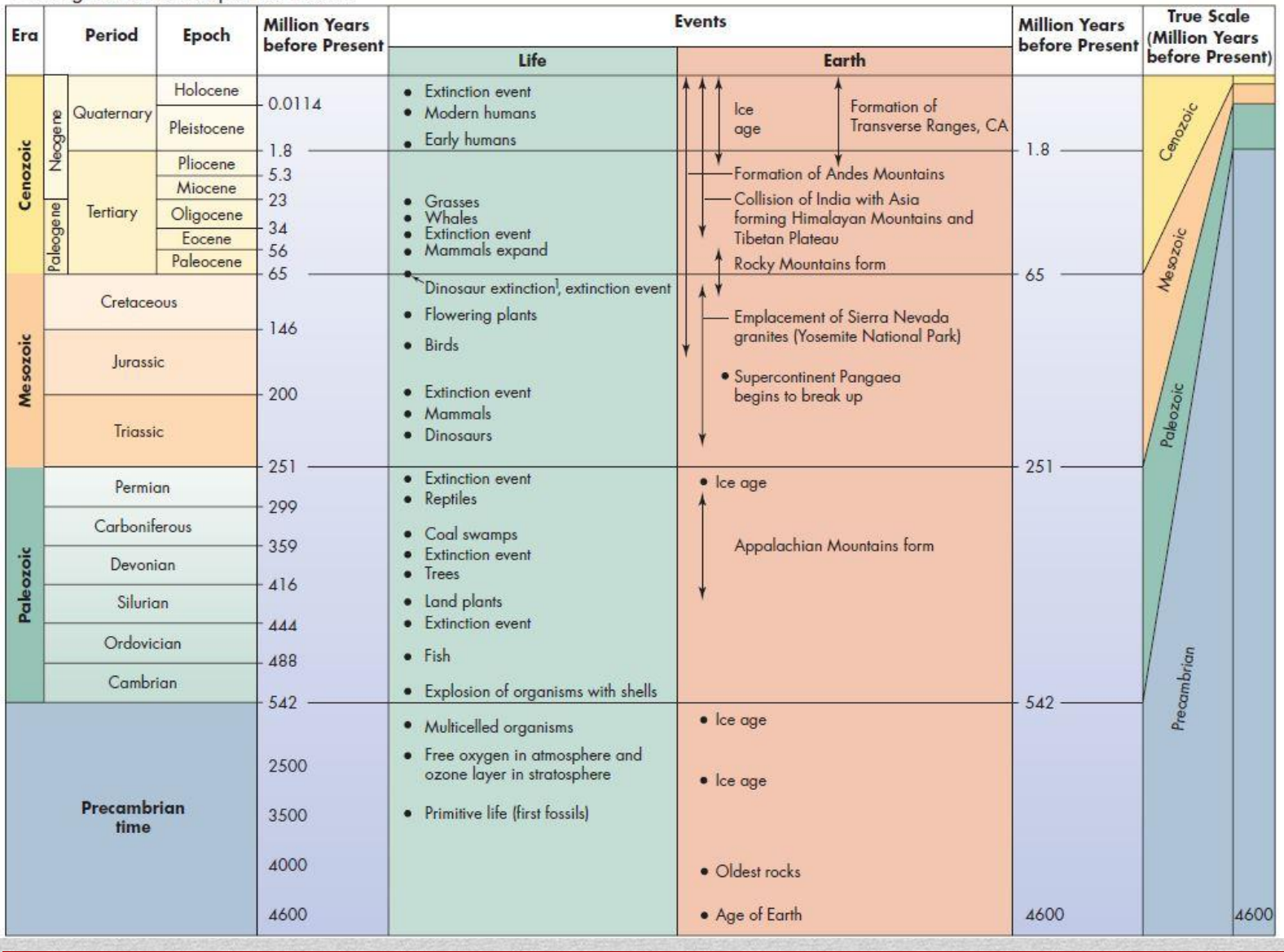
Concept: 1
Hazards are Predictable from Scientific Evaluation

- Science and Natural Hazards
  - Use of the Scientific Method
    - Formulate a question
    - Develop a hypothesis
    - Test the hypothesis with experiments
  - From the results of the experiments, develop a conclusion
- Use Scientific Method to understand and develop a predict natural hazards


SCIENTIFIC METHOD
PURPOSE
State the problem.
RESEARCH
Find out about the topic.
HYPOTHESIS
Predict the outcome to the problem.
EXPERIMENT
Develop a procedure to test the hypothesis.
ANALYSIS
Record the results of the experiment.
CONCLUSION
Compare the hypothesis to the experiment's conclusion.

- **Hazards are Natural Processes**
  - Modern humans seem to be a product of the Pleistocene ice age of 1.8 million years ago
    - There has been rapid climate change from harsh glacial conditions to a few thousand years ago when the climate began to warm.
    - We had to learn to "adapt and overcome" these climate chances in order to survive.
  - Events we call **Natural Hazards** are **Natural Earth processes**
  - These **natural processes** only become **hazards** when they happen **where people are**
  - They become **hazards** when we humans change the land-use by urbanization or by deforestation.
  - We, as humans, should realize these hazards, and try **minimize these processes**

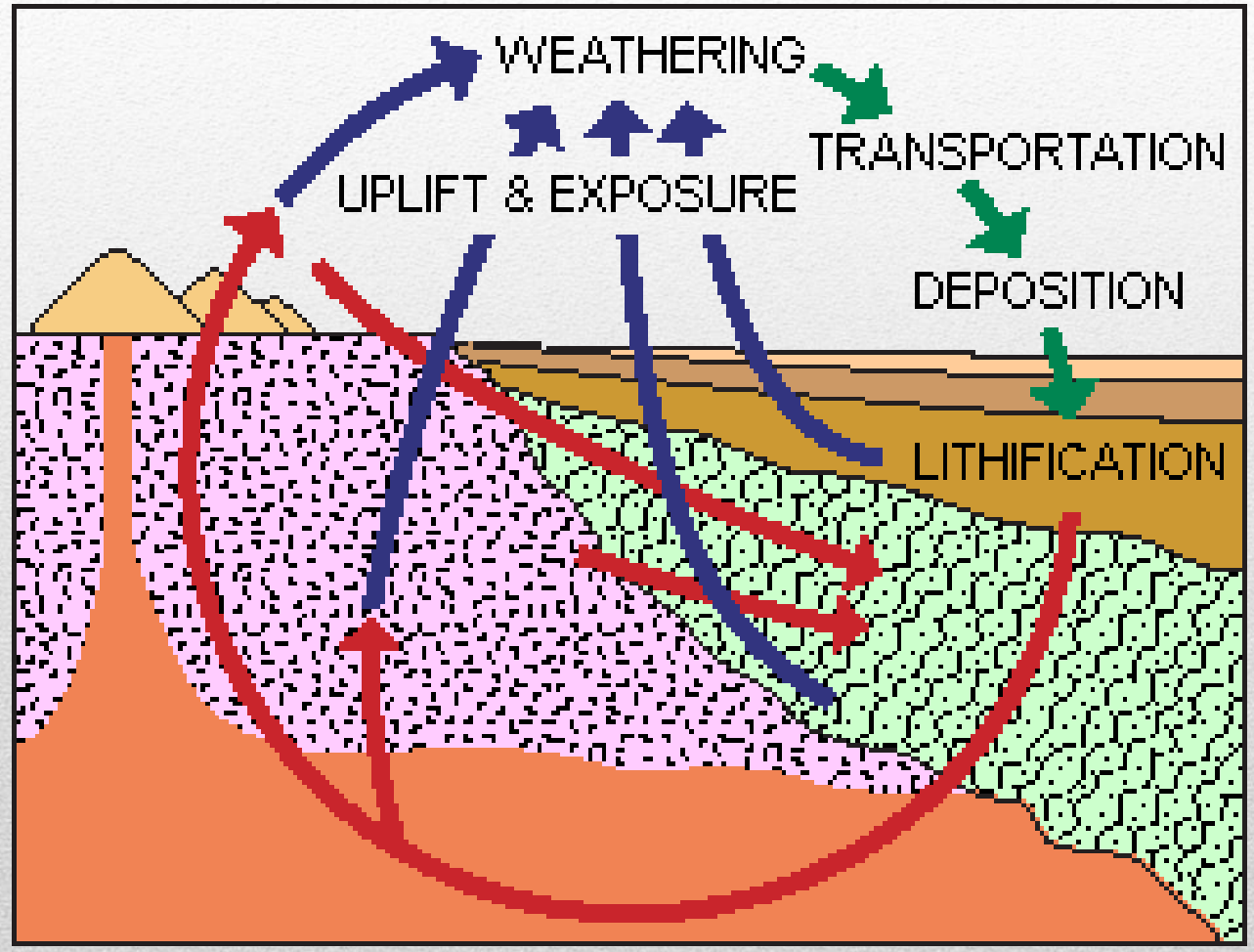
Geologic Time with Important Events



Forecast, Prediction, and Warning

- **Predicting Changes in the Earth System**
  - **Uniformitarianism:** "*the present is the key to the past.*"
    - The fundamental concept of earth sciences is as the earth processes wear down the earth's surface, the earth processes builds the surface back up
    - Human activities can effect these changes
- Now we have to look at:
  - **Environmental Unity-** "*the present is the key to the future.*"
    - One action causes others in a chain of actions and events
    - "Removal of vegetation on a steep hillsides can bring on landslides in a rain storm"

Uniformitarianism



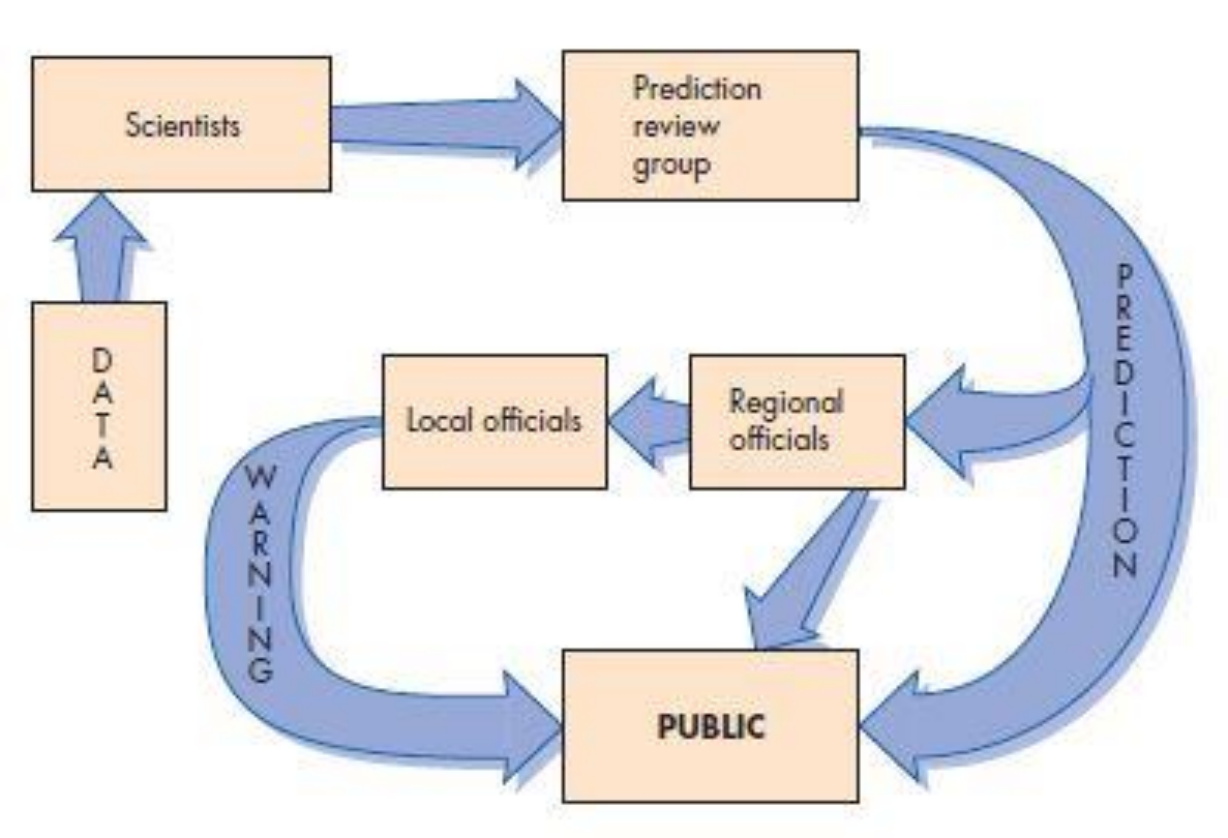
Forecast, Prediction, and Warning

- **Prediction** involves specifying the **date**, **time**, and **size** of a hazardous event
  - Different from predicting where or how often a particular event will occur
- A **forecast** has a **range of certainty**. This involves a percentage of certainty that an event will happen.
  - By giving a **forecast** of an event, the loss of life can be minimized and there will be less property damage
- **Study of natural hazards** helps in the improvement in **forecasting** when the events will happen
- By knowing the **probability and the possible consequences** of an event, we can assess the risk of that event and give **warnings**

Forecast, Prediction, and Warning

- **Minimizing the effects of a hazardous event by:**
  - **Identifying the location** where a hazardous event is likely to occur
    - Mapping the kind of hazardous events and where they might happen around the world
  - **Determining the probability** that an event of a given magnitude will occur
    - Determine the probability of a particular event in a particular location within a particular time span
  - **Observing any precursor events**
    - Many hazardous events are preceded by *precursor events*
  - **Forecasting or predicting** the event
    - When a forecast of an event is issued, the certainly is given in a percentage of an event happening
    - Using the four preceding methods, a prediction can be made that an event will happen
  - **Warning** the public
    - Information of the possibility of a hazardous event happening

Forecast, Prediction, and Warning



Concept 2:
Risk Analysis: Understanding the Effects of Hazardous Processes

- **Risk of a particular event**
  - The product of the probability of that event occurring the times the consequences should it occur.
  - **Consequences** may be expressed on a variety of scales

- Determining ***acceptable risk*** is complicated . This depends on the situation.
  - Governments may require a person to get flood insurance if there is a high risk of flooding in the area that live
  - Individuals can choose where they live if there is a possibility of flooding, earthquakes, hurricanes and even a volcano eruption

Concept 3: Linkages

- Connections exist between Natural Hazards and Hazards and the Physical Environment
- These are called **Linkages**
  - Volcanic eruptions on land are linked to mudflows and floods
  - Eruptions in the ocean are linked to tsunamis
- **Natural hazards are linked to earth materials**
  - Exposures of shale to landsides
  - Granite to large fractures of rock

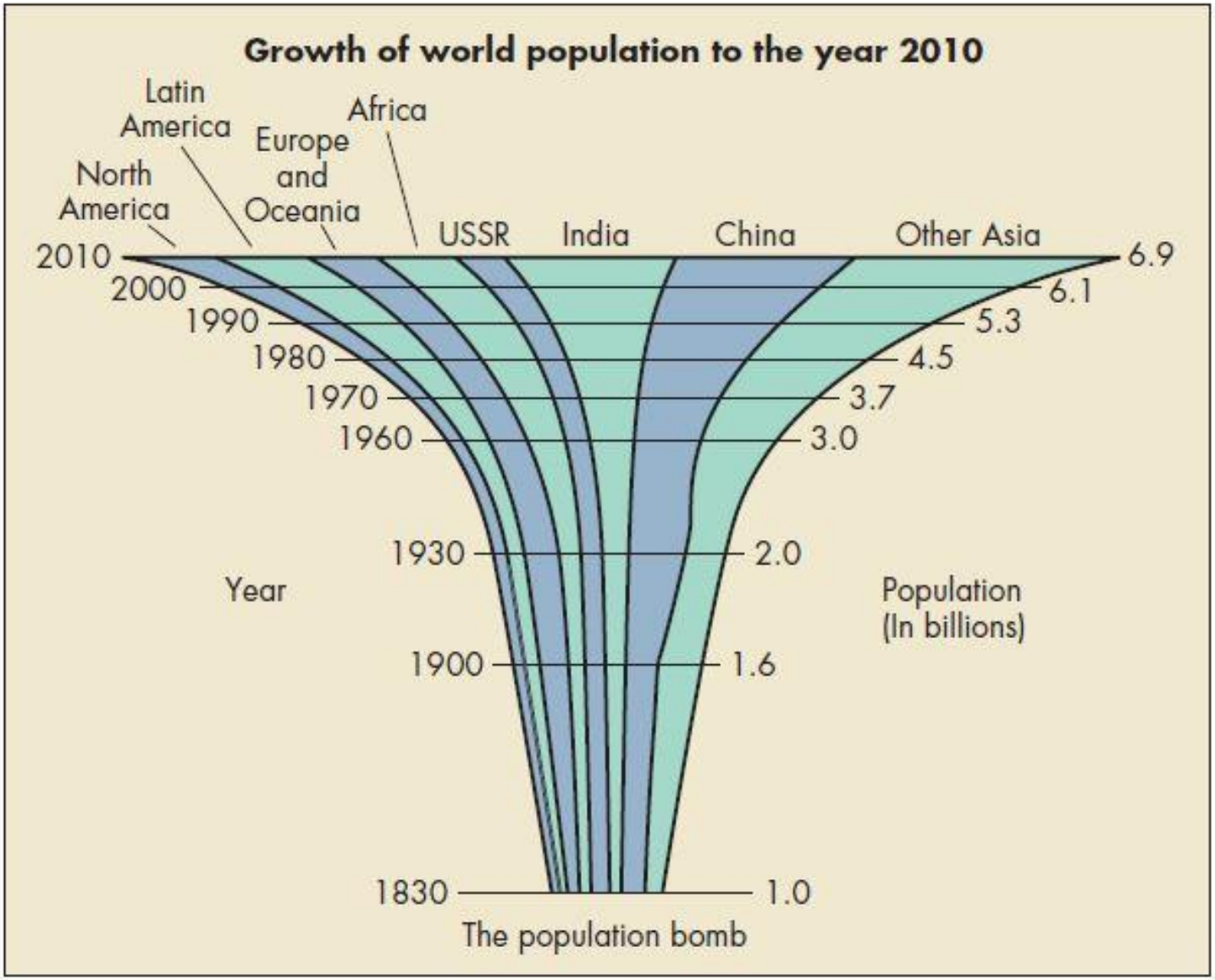
Concept 4:
Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes

- As the earth's **population has increased, natural hazards that once caused disasters, now cause catastrophes**
- This **population was soon civilized, lived closer together and built large cities**. As this happens a **disasters becomes a catastrophes**

  - Example: Mexico City built on an ancient lake bed, in September of 1985 experienced a magnitude 8.0 earthquake, killing 10,000 people.
  - Example: Japan's earthquake and tsunami in 2011. Magnitude 9.0, 10 meter high tsunami waves, 16,000 killed

Concept 4:
Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes

- Increase in the population growth
  - Between 1830 to 1930 – **100 years**, the world population increased from **1 to 2 billion**
  - Between 1930 to 1970 – **40 years**, the world population increased to **4 billion**
  - Between 1970 to 2000 – **30 years**, the world population increased to **6 billion**
  - And from 2000 to July 1, 2013 – **12 ½ years**, the world population increased to **7.16 billion people**
- This is why, if a **natural hazard does occur, it will most likely will either be a disaster or a catastrophe**


Growth of world population to the year 2010
Latin America
Africa
Europe and Oceania
North America
USSR
India
China
Other Asia
2010
2000
1990
1980
1970
1960
1930
1900
1830
6.9
6.1
5.3
4.5
3.7
3.0
2.0
1.6
1.0
Year
Population (In billions)
The population bomb

Concept 4:
Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes

- **Magnitude and Frequency of Hazardous Events**
  - The ***impact*** of a hazardous event is in part a function of the amount of energy release, that is the **magnitude** and the interval between occurrences, its **frequency**
  - The ***impact*** is also influenced by other factors including:
    - Climate
    - Geology
    - Vegetation
    - Population
    - Land-use
  - Learning to look at these and other factors on natural hazards may **lessen these impacts** on the **rising population.**

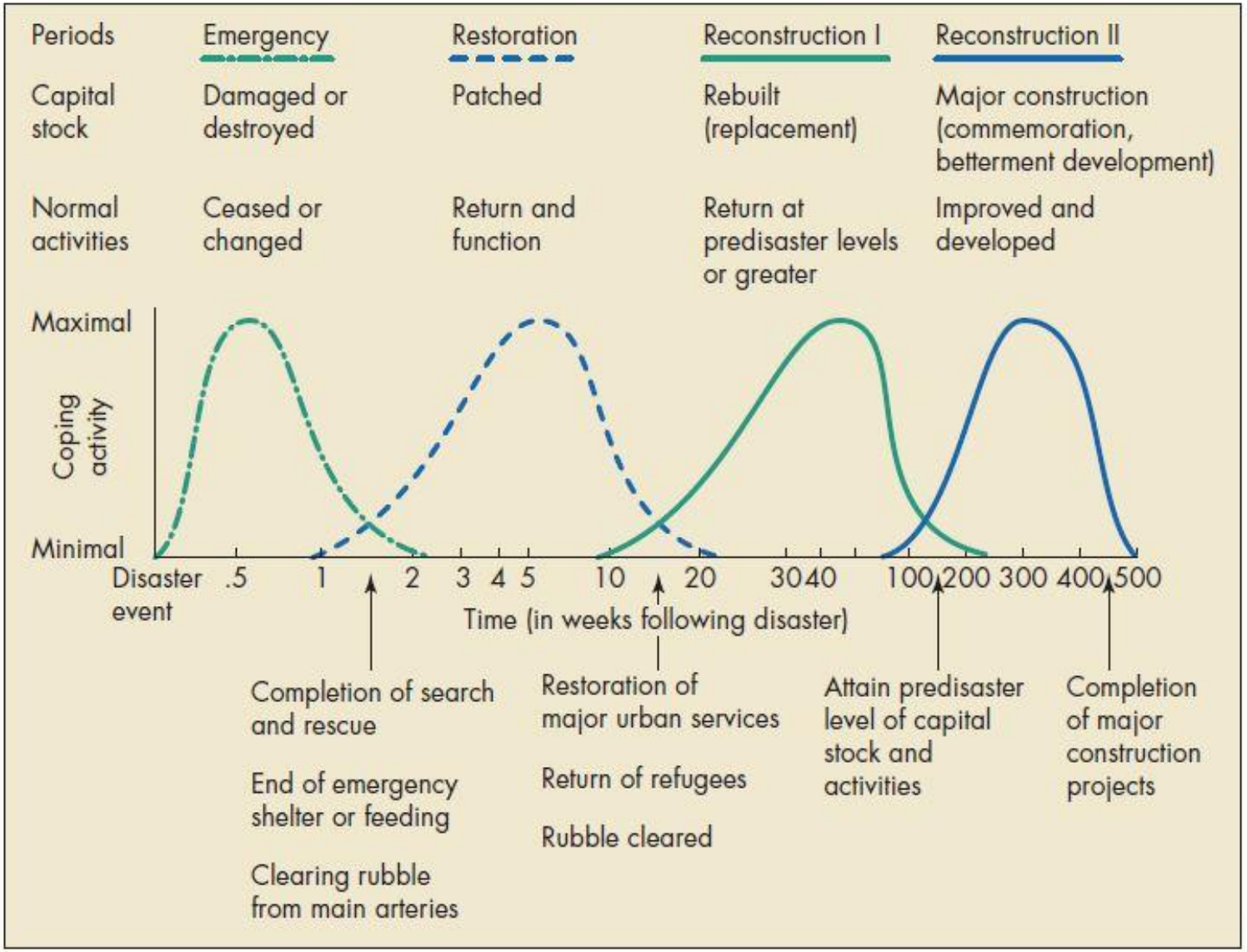
Concept 5:
Consequences of Hazards Can Be Minimized

- Many times we deal with natural hazards in a ***reactive*** way.
- Following a disaster, we engage in
  - Search and rescue
  - Firefighting
  - Providing food, shelter, and medical care
- This **does reduce** the lose of life and property

- **BUT: to move to a higher level of hazard reduction requires increased efforts to anticipate disasters and their effects.**

Concept 5:
Consequences of Hazards Can Be Minimized

- Reactive Response: Impact of and Recover from Disasters
  - The effect of a disaster upon a population may be either *direct* or *indirect*
    - Direct Effects:
      - People getting killed, injured, dislocated, or otherwise damaged
    - Indirect Effects:
      - Emotional distress, donation of money or goods, and the paying of taxes to pay for the recovery of property
  - Direct effects are felt by fewer individuals, whereas indirect effects affect many more people


Periods
Emergency
Restoration
Reconstruction I
Reconstruction II
Capital stock
Damaged or destroyed
Patched
Rebuilt (replacement)
Major construction (commemoration, betterment development)
Normal activities
Ceased or changed
Return and function
Return at predisaster levels or greater
Improved and developed
Maximal
Coping activity
Minimal
Disaster event
.5
1
2
3
4
5
10
20
30
40
100
200
300
400
500
Time (in weeks following disaster)
Completion of search and rescue
End of emergency shelter or feeding
Clearing rubble from main arteries
Restoration of major urban services
Return of refugees
Rubble cleared
Attain predisaster level of capital stock and activities
Completion of major construction projects

Concept 5:
Consequences of Hazards Can Be Minimized

- **Stages of recovery** following a disaster are
  - Emergency work
  - Restoration of Services and Communication Lines
  - Reconstruction
- **Life returns to normal basically**

- **Reconstruction II:**
  - Planning is essential!!
  - Don't rush – evaluate how best to use recovery funds to rebuild to withstand future hazards
  - **Rebuild to reduce damage and loss of life if another event should happen**


RISK REDUCTION
PREVENTION
PREPAREDNESS
RESPONSE
RECOVERY
MITIGATION
DISASTER

Concept 5:
Consequences of Hazards Can Be Minimized

- **Anticipatory Response: Avoiding and Adjusting to Hazards**
  - There is a **need to minimize the effects of disasters by evaluating the perception of the hazards**
  - People need to be **educated to understand natural hazards** and **how they should deal with an event should they be involved in one**

Concept 5: Consequences of Hazards Can Be Minimized

- There are many ways which can be used to help reduce the consequences of natural hazards
  - **Careful planning for land-use**
    - Don't build on a flood plain
  - **Insurance**
    - Have flood or earthquake insurance
  - **Evacuation**
    - Have a plan if something happens
  - **Disaster Preparedness**
    - Training and organization
  - **Have an artificial control of Natural Processes**
    - Sometime they work, sometimes they don't
  - **Too often the option is to simply bear the loss**

Hazards Can Provide a Natural Service Function

- Somewhat **ironic**:
  - **<u>Natural events which take human life and destroy property are often a benefit or natural service to nature</u>**
    - **Periodic flooding supplies nutrients** to the land it floods.
    - **Forest fires** will release new seeds to for new growth
      - Uintah Forest, eaten by a deadly beetle, waiting to burn, will get rid of the beetle and the dead trees, and begin re-growth
    - **Landslides** will **dam up stream** and make a lake for **important water storage**
    - If the **dam breaks**, then the **land downstream is rejuvenated**
    - The **Hawaiian Islands** are **growing due to lava flow** from the volcano eruptions

Global Climate Change and Hazards

- **Global and Regional Climate Change**
  - **Could affect the incidence of hazardous natural events such as storms, landslides, drought, and fires**
- **What might this happen to cause these increases?**
  - Sea level is rising and growing warmer
  - Erosion is increasing
  - Shift in precipitation and development in deserts and semiarid lands
  - Warming of the northern latitudes could become more productive, leading to population shifts
    - Could cause more wars, social and political upheavals
  - Increase in energy in the atmosphere causing more thunderstorms and hurricanes